6-2002

Geospatial Information Technologies for Mobile Field Data Collection

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Abstract
Federal statistical agencies generate critical data about the nation's population, economy, and natural resources. These data are gathered largely by mobile field data collection. Although geospatial information is an essential reference material in the field and serves as a base for recording spatially-linked data, it is nearly always used in printed forms due to limitations in mobile computing systems and tools for handling geospatial data. The ability to interact with digital geospatial data in the field offers significant enhancements for data quality and operational efficiencies. In this paper, we briefly summarize research on extensible infrastructure designs for limited field computing environments and appropriate field tools for mobile data gatherers.

Disciplines
Statistics and Probability

Comments
This preprint was published as Sarah Nusser, Leslie Miller, Keith Clarke, and Michael Goodchild, "Geospatial IT for Mobile Field Data Collection", *Communications of the ACM* (2003): 45-46, doi: 10.1145/602421.602446.

GEOSPATIAL INFORMATION TECHNOLOGIES FOR MOBILE FIELD DATA COLLECTION

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June 30, 2002

Federal statistical agencies generate critical data about the nation's population, economy, and natural resources. These data are gathered largely by mobile field data collection. Although geospatial information is an essential reference material in the field and serves as a base for recording spatially-linked data, it is nearly always used in printed forms due to limitations in mobile computing systems and tools for handling geospatial data. The ability to interact with digital geospatial data in the field offers significant enhancements for data quality and operational efficiencies. However, basic research is needed on extensible infrastructure designs for limited field computing environments and appropriate field tools for mobile data gatherers.

Project Battuta (http://dg.statlab.iastate.edu/dg) seeks to enable access to and use of digital geospatial information for field data gatherers who do not have extensive training in spatial analysis or information systems. We assume users need seamless access not only to geospatial information resources prepared for the field campaign, but also to data available online (Figure 1).

Mobile field computing environments vary widely, but generally offer extremely limited computing resources, visual display, and bandwidth relative to the usual resources required for distributed geospatial data. Key to handling heterogeneity in the field is an infrastructure design that provides flexibility in the location of computing tasks and returns information in forms appropriate for the field computing environment. Our view agent infrastructure model addresses these issues with several components (Figure 2). Wrappers are used for encapsulating not only the data sources, but the mobile field environment as well, localizing the details associated with heterogeneity in data sources and field environments. Within the boundaries of the wrappers, mediators and object-oriented views implemented as mobile agents work in a relatively homogeneous environment of manipulating XML-encoded data to generate query results. Mediators receive a request from the user application via the field wrapper, and generate a sequence of mobile view agents to search for, retrieve, and process data. The internal infrastructure environment is populated with computation servers to provide an infrastructure location for processing, especially for combining data from multiple sources. Each computation server has a local object-oriented data warehouse equipped with a set of tools for working with geospatial data. Since the prospect of query reuse is likely for a field worker, we store the final and intermediate results in the data warehouse, allowing the warehouse to act as an active cache.

Even when field computing capacity is ample, the warehouse is used to process data so that network traffic can be minimized.

Because it will not always be possible to rely on infrastructure computing resources, tools are needed for working with geospatial data in the field. We are focusing on field-based data integration in the face of positional inaccuracies to handle conflation, or the combination of geospatial data sets that represent at least in part the same phenomena in overlapping geographic areas. Conflation software has been developed to remove unacceptable differences in two sources, such as a road network and an orthophotograph, using Global Positioning System (GPS)-determined positions or a positionally accurate source. A second field tool under development will enable users to adaptively select samples in response to new information gathered in the field, such as the identification of a contaminant hot spot or a rare species.

An intriguing advance in field data collection is the ability to combine GPS-derived positional context with geospatial data. Related projects sponsored by collaborating agencies are demonstrating the enhancements these tools bring to field operations. We are extending this integration of user perspective, digital information resources, and surrounding reality through visual augmentation, designed to combine spatial information such as user position, digital maps, and auxiliary information about a household, with views of the physical environment. Using a prototype wearable system, with input from a digital compass and GPS receiver and output to a viewer clipped to a pair of glasses (Figure 3a), we are exploring a navigation mode that leads the user through geographic space, using prior paths or computed navigation information. A second mode focuses on positioning, where assistance to the user in geographic positioning and spatial alignment are given. We are investigating aspects of the user interface that such a system would require, including icons and graphics for the two modes, and map-based displays within the visual interface (Figure 3b).

Project Battuta investigations are being explored via a testbed for environmental and demographic surveys, and are readily extensible to less structured information gathering settings such as crisis management and law enforcement.

Acknowledgements

This research is supported in part by funds provided via NSF Digital Government grant EIA-9983289 and the following collaborating agencies: Bureau of the Census, Bureau of Labor Statistics, U.S. Department of Agriculture (Forest Service, National Agricultural Statistics Service, Natural Resources Conservation Service), and U.S. Geological Survey.

Figure 1. The Project Battuta model assumes data gathers need access to pre-specified information resources prepared for the data collection campaign (lower left) as well as other unspecified resources available online (lower right), via a seamless interface with an infrastructure that handles the user request and returns products that are appropriate for the field computing environment.

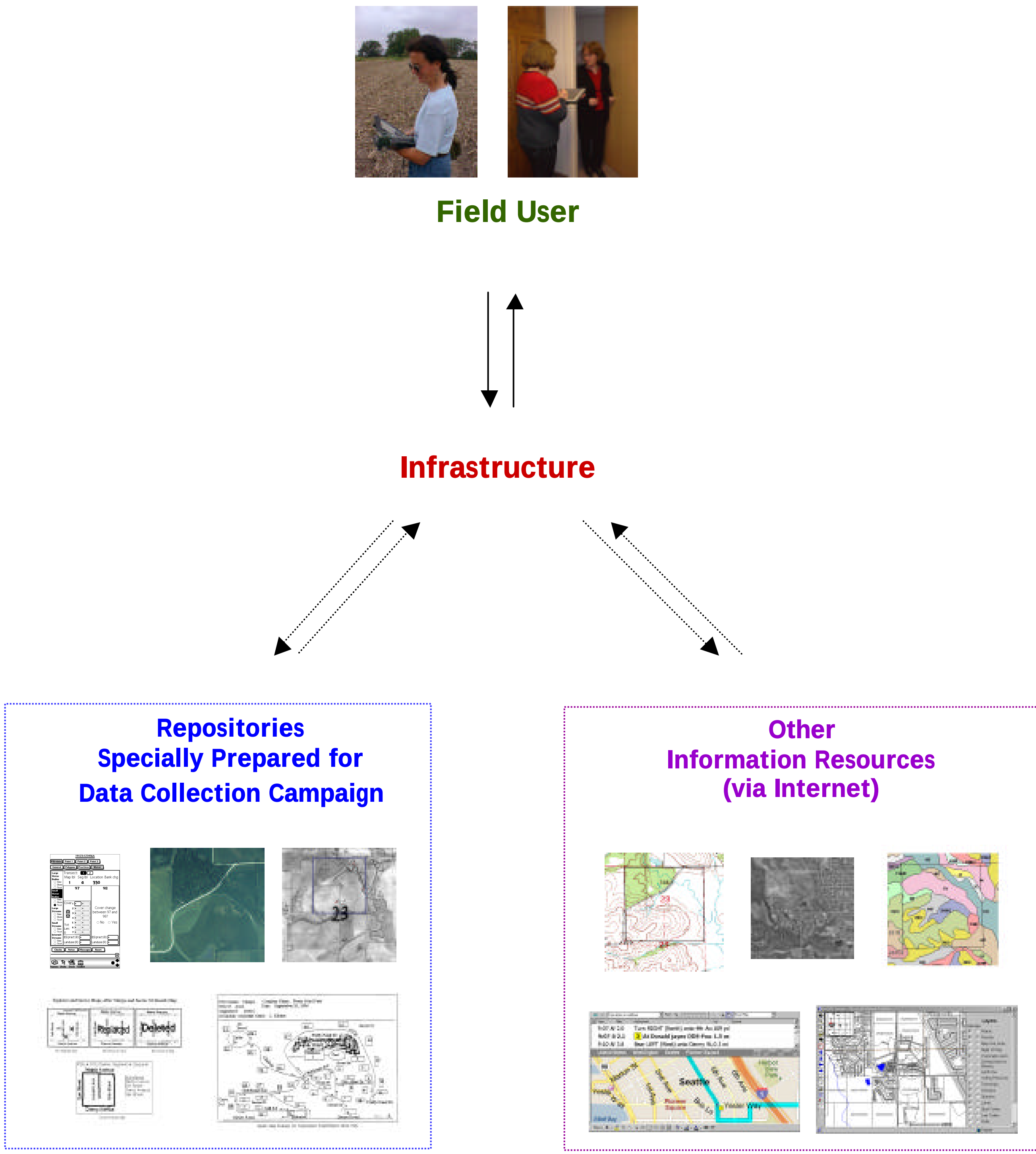

Figure 2. The underlying infrastructure model includes wrappers to encapsulate the field computing environment and the data sources, mediators that spawn a sequence of mobile agents in response to a query, and a computation warehouse that processes and stores geospatial data as needed to fulfill the request and support further queries.

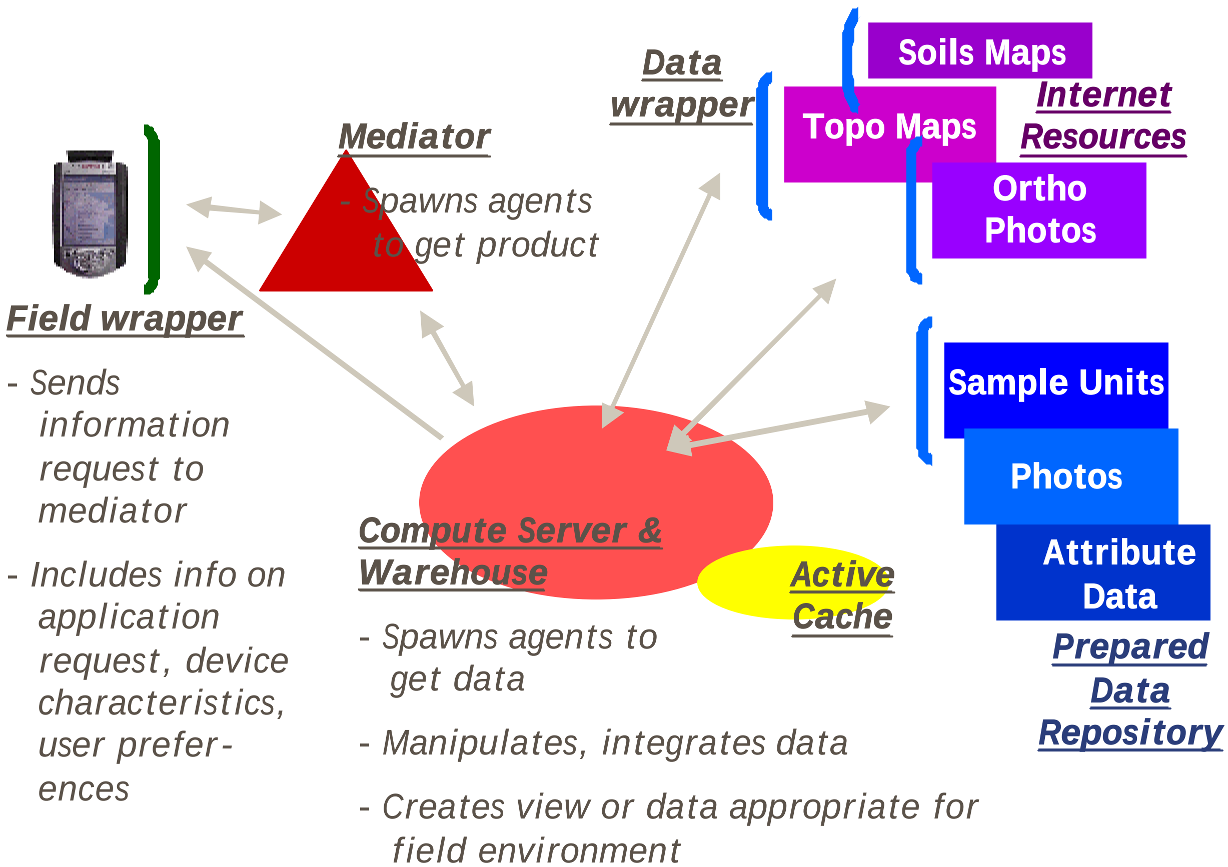

Figure 3a. The Project Battuta prototype wearable system includes a digital compass, GPS receiver, and displays computer output through a viewer clipped to a regular pair of glasses.

Figure 3b. Some ideas for appropriate interfaces to assist a user in navigation include displaying web resources, floating arrow glyph indicating a path, and augmented information superimposed on a real structure such as a building.